# A Priority Research Agenda for Understanding the Influence of the Common Core State Standards for Mathematics

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# A Priority Research Agenda for Understanding the Influence of the Common Core State Standards for Mathematics

The Common Core State Standards for Mathematics (CCSSM) are part of a broader effort coordinated by the National Governors Association Center for Best Practices and the Council of Chief State School Officers to develop common state standards in key subjects. Released in 2010, the CCSSM are intended to provide a blueprint for the mathematics that students should learn in their K-12 education, and when they should learn that mathematics. To help ensure that all students will be prepared to succeed in society and in our global economy, the CCSSM are intended to align with expectations for both college and career readiness. These expectations include studying rigorous content benchmarked to international standards; focusing on deeper study of fewer topics than has generally been the case in mathematics education in the United States; and attending to coherence by connecting ideas within and across topics. Although the CCSSM effort is state-driven, the federal government provided support for the initiative in the form of incentives for states to adopt the standards as part of the Race to the Top competition, and by funding two assessment consortia.

The CCSSM specify content learning goals by grade in K–8 and by conceptual categories in the high school grades. In addition, there are eight standards for mathematical practice to be addressed throughout K–12 mathematics education, describing fundamental approaches to, and dispositions toward, learning and doing mathematics. The idea of "standards progressions" is central to the CCSSM, specifying the content to be addressed as well as the connections to be made. Although states are expected to adopt the CCSSM in their entirety, adopting states have the option to include up to 15 percent in additional standards at their discretion.

States, districts, schools, and teachers may choose to follow, or not follow, the CCSSM specifications; and those that do will likely differ in how they interpret the standards, what they plan to do in response, and their capacity to implement their plans. As a result, and because of considerable differences among school contexts and student populations, common standards are not likely to lead to the same results, either in implementation or in impacts on students. Our goal in this project was to suggest a set of priorities for research that would provide the field with a reasonably broad and deep understanding of the influence of the CCSSM. The priority research agenda recommends a set of case studies, investigations of relationships, and status studies to address three overarching questions: (1) How is the mathematics education system responding to the introduction of the CCSSM? (2) What happens, and for whom, as a result? and (3) How can the CCSSM and future standards be improved? The purposes of this priority research agenda are to inform funders of mathematics education research about important areas of investigation to consider supporting, and to suggest to the mathematics education research community focal areas of study to build the field's knowledge about the influence of the CCSSM.

# DEVELOPING A PRIORITY RESEARCH AGENDA

In considering research for monitoring the effects of the CCSSM, we had the benefit of being able to build on earlier work focused on research on national standards. A committee convened by the National Research Council (NRC) developed a framework for research on the influence of national standards documents (Weiss, Knapp, Hollweg, & Burrill, 2002). The NRC framework is based on the recognition that standards documents are unlikely to have a direct impact on student learning, but come to influence teaching and learning by first influencing key components of the education system, including curriculum, assessment, and teachers. This framework suggests that understanding the influence of a set of standards requires investigating how the standards are being received and interpreted; the actions that have been taken in response to the standards; what has changed as a result; and who has been affected and how. Although the NRC framework is intended to be applicable to a wide range of standards, it seems clear that priorities for what should be investigated for a particular set of standards depend on the nature of those standards, the theory of action underlying their development and implementation, and the potential unintended consequences.

The process we used to develop the priority research agenda involved review of relevant documents, interviews with some of the key people involved in the CCSSM initiative, and considerable input from the field. Data collection activities included:

1. Review of Common Core State Standards documents (Common Core State Standards Initiative, 2010a, 2010b, 2010c, 2010d), and interviews with the authors of the CCSSM to understand the intent of these standards;

2. Interviews with representatives of the groups that are coordinating the Common Core State Standards Initiative to understand how they intended the CCSSM to influence the system;

3. Meetings of small groups of mathematics education and policy researchers to consider a conceptual framework for research on the influence of the CCSSM;

4. Surveys of mathematics educators to get input on how the CCSSM might influence mathematics education, both positively and negatively; and

5. A two-day conference of mathematics education and policy researchers to consider priorities for research.

The CCSSM describe the mathematics that students should learn, and when they should learn it, with the expectation that following this plan will enable K–12 students to gain the mathematical knowledge that will ensure that they are college and career ready when they graduate from high school. Clearly it would not be feasible to study in depth how the CCSSM are influencing every part of the mathematics education system, nor to examine the effects of that influence on mathematics teaching and learning in every classroom in the United States. In order to develop a priority research agenda, we considered how the CCSSM were intended to influence mathematics education, and possible unintended consequences in determining which of the many

components of the system that could be studied were most important to study, how, and when, in order to understand the influence of the CCSSM.

Project data collection highlighted a number of elements of how the CCSSM are expected to foster collaboration among states in adding clarity, coherence, and focus to the mathematics education system, helping to ensure that students in every school, in every participating state, have the opportunity to learn important mathematics. For example:

> *The standards clearly communicate what is expected of students at each grade level. This will allow our teachers to be better equipped to know exactly what they need to help students learn and establish individualized benchmarks for them. The Common Core State Standards focus on core conceptual understandings and procedures starting in the early grades, thus enabling teachers to take the time needed to teach core concepts and procedures well—and to give students the opportunity to master them.…With students, parents and teachers all on the same page and working together for shared goals, we can ensure that students make progress each year and graduate from school prepared to succeed in college and in a modern workforce.* (Common Core State Standards Initiative, 2010c)

In interviews, leaders of the CCSSM initiative suggested that having common standards across states would help in improving mathematics education more broadly than has been the case in past initiatives. In particular, they expect common standards to result in economies of scale and sharing of best practices, as the likelihood that efforts will be applicable across states should provide greater opportunity and incentive to collaborate. Similarly, materials and programs produced by third-party and commercial entities are expected to become more broadly applicable across states that have adopted common content standards. Finally, the existence of common standards is expected to promote the concentration of expertise in developing not only resources, but also capacity and infrastructure for implementation of rigorous standards.

At the same time, both "insiders" in the Common Core State Standards Initiative and people who were not involved in their development identified a number of possible unintended consequences of the CCSSM effort. Some mathematics educators we queried do not expect the system to become aligned around this set of mathematics standards, whether due to lack of capacity, uneven commitment, and/or inadequate resources. Others expressed concern about the consequences to student learning if the system does in fact align around the Common Core State Standards. In particular, there is concern that: (1) the standards progressions are not adequately grounded in research on learning; (2) some content areas are not given sufficient emphasis; (3) there is inadequate attention to the use of technology; and that (4) rather than leveling the playing field, the way the CCSSM are implemented may lead to increased barriers for students in traditionally low-performing subgroups. In addition, there is concern that the CCSSM, and the assessment systems developed in conjunction with them, may have a dampening effect on innovation in content, curriculum materials, and assessment, consequently limiting the ability of the field to generate knowledge about effective mathematics education. Finally, a general theme among both the promoters of the CCSSM and the mathematics educators we queried who are external to the process was that if the CCSSM initiative results in only superficial, cosmetic changes, we will not see improved student performance.

Research can and should be conducted to determine how the introduction of the CCSSM affects mathematics education in the United States. To be sure, research on the influence of the CCSSM should focus on key elements of those standards, including not only the extent of emphasis on topics that are identified as central, but also whether mathematics curriculum is becoming more focused and coherent, and the mathematical practices are being addressed as intended. At the same time, there are many factors that are beyond the scope of the CCSSM initiative that might well affect outcomes, such as principal support for mathematics education, teacher expectations about student learning, and the quality of classroom discourse, just to name a few. In carrying out the priority research agenda outlined in this report, or in additional studies related to the CCSSM, it is important that researchers specify and study these other elements of the system as appropriate to their expertise, interest, framing of the research, and trends in the field.

In the near term, investigating whether and how the hypothesized benefits and potential negative consequences are unfolding can provide early warnings, for example of gaps in capacity and infrastructure, and help in fine-tuning efforts to implement the CCSSM. However, the field should not rush to judge this, or any other, set of standards a success or a failure. In the early stages, if standards have not been well implemented in a particular setting, then poor student performance shouldn't be blamed on those standards. Judgments of the effectiveness of the CCSSM should be based on evidence of two kinds: (1) the extent to which the CCSSM can be well implemented at scale, and (2) whether they produce the desired results when they are implemented as intended.

## PRIORITY RESEARCH AGENDA

Project staff used information resulting from our initial data collection activities to identify 12 "priority lines of inquiry," which were described in a draft report. Feedback from reviewers with diverse perspectives on the CCSSM and on education research indicated a need for a smaller number of priority areas, with fewer research questions. The research agenda below reflects that recommendation, and incorporates reviewers' feedback on key research questions. [1]

This priority research agenda was developed with considerable input from mathematics education and policy researchers. (See Appendix A for a list of contributors.) It takes into account the defining features of the CCSSM; key leverage points in the system; both how the CCSSM are intended to influence the system and possible unintended consequences; and what can be learned

[1] Detailed information on how the priority research agenda was developed; a description of the 12 initial lines of inquiry; and a summary of reviewers' feedback on each can be found in the project technical report (Heck, Weiss, & Pasley, 2011), which is available from http://www.horizon-research.com/reports/2011/CCSSMresearchagenda/technical_report.php

from various types of research.[2] Another important consideration in designing research on the influence of the CCSSM is the strategic choice of mathematics content on which to focus. The CCSSM represent substantial shifts in some content areas, but are quite similar to prevailing practice in others. As a consequence, research on some content areas will be more telling than others regarding the influence of the CCSSM. Topics for which the primary change is that the CCSSM provide greater or lesser emphasis than is typically the case currently can be investigated to determine if corresponding changes in emphasis occur in various parts of the system. However, additional areas of "telling content" should be identified, such as where the mathematical treatment or progression of ideas is quite different in the CCSSM than is currently predominant. For these topics, qualitative changes in the mathematical approach, sequence, and connections would be important to investigate. The standards for mathematical practice should also be a focus of research because they are intended to be a central part of mathematics education across K–12 grade levels.

We believe that implementing sets of studies based on this research agenda will generate knowledge that will be useful in improving the implementation of the CCSSM, and in improving both the design and implementation of future sets of standards. The suggested research priorities are approached through a variety of studies that, taken together, will provide both broad and deep knowledge about the influence of the CCSSM. First, the recommended priority research agenda includes case studies focused on system components that are expected to exert strong leverage, as well as case studies to look deeply into the decisions and actions of states and districts as they respond to the CCSSM, and the consequences. These studies can yield careful descriptions that offer insight into not just what influences are evident, but how and why those influences came about. Case studies are particularly well suited for these targets of research because they can be responsive to both anticipated and unanticipated developments, can examine potentially different points of view at play, and can attend to the role of context.

Second, the proposed research agenda includes relational studies, initially proofs of concept, then broader studies of conditions of effectiveness, and finally experiments to determine whether interventions can produce conditions of effectiveness in various contexts. The purposes for these three types of studies are different and complementary. Proofs of concept are generally opportunistic, or conducted under fairly special circumstances; they can be used to establish the viability of a particular relationship. Broader studies of the conditions of effectiveness extend beyond those special circumstances to examine the range of conditions under which particular relationships exist, and for whom. These studies can also offer explanations of why and how particular conditions result in various outcomes. Finally, experiments/quasi-experiments are useful for establishing whether creating particular conditions in fact facilitates the relationships of interest, and for whom.

[2] It is important to note that while the priority research agenda provides recommendations for what is most important to study, it stops well short of study designs. It was beyond the scope of our project to do the extensive review of the literature necessary to describe what is already known in each of these key areas; determine how current understanding needs to be taken into account in designing research studies; specify indicators that components of the system being investigated are or are not aligned with the CCSSM; identify instruments that could be adapted for use in research on the influence of the CCSSM, etc.

Third, the priority research agenda includes status studies, some that involve secondary analysis of data available through on-going data collection efforts; others that piggyback onto existing efforts by adding a focus on the CCSSM; and some newly-crafted endeavors specific to the CCSSM. Status studies are particularly useful for taking broad snapshots of indicators of the health and quality of the mathematics education system at a given point in time, and for examining variations over time. They can be conducted on large, representative samples, lending themselves to disaggregation in order to investigate status and trends within subgroups and specific contexts of interest, and to compare status and trends across subgroups and contexts.

For a number of questions throughout the research agenda, we emphasize the importance of attending to various subgroups of students who are educated in different contexts, to underscore the importance of disaggregating results, attending to potentially differential findings, and conducting targeted studies to investigate questions regarding equity of opportunity and outcomes. The term "various subgroups of students" is intended to include variations in socioeconomic backgrounds, gender, race/ethnicity/culture, language, immigration status, disability state, and educational needs. It is also intended to highlight the need for studies to investigate opportunities and outcomes for students whose academic achievement of the CCSSM lags behind, meets, or exceeds expectations. Similarly, the phrase "educated in different contexts" is intended to emphasize the need to attend to, and target studies to, varying state, district, community and family, school, and classroom (including virtual and distance learning) settings.

To support cumulation of knowledge, research efforts drawing on any of these approaches must be conducted with attention to quality and rigor in design, conduct, and reporting. Cumulating knowledge also depends on establishing shared definitions for some key terms, so that differences in meaning for the same words, or the use of different words to represent the same ideas, do not obscure real points of agreement or disagreement. Along with the priorities for research, this report offers a set of methodological considerations, both to strengthen the evidentiary basis for the claims and conclusions of individual research studies, and to enrich the broader enterprise of research on the influence of the CCSSM.

The priority research studies are organized and described below by study type. This choice of organization was useful for providing the rationale and specifying research questions for each recommended focus of research. This organization, though, is not meant to imply prioritization of study types. Further prioritization within these recommended sets of studies should be considered in terms of when particular studies are likely to be most informative, and what aspects are most critical to understand about the response of the system, the resulting outcomes, and evidence to improve the standards. We present a brief discussion of these considerations, organized by the three overarching questions presented in the introduction, followed by further explication of the recommended studies. Within each study type, the most essential priorities are listed first and indicated with an asterisk (*), followed by other high priority studies. Setting priorities, by its nature, requires difficult choices. Additional areas for research that are both interesting and important are included in Appendix E.

• **How is the mathematics education system responding to the introduction of the CCSSM?**
Efforts to implement the CCSSM began as soon as they were released; publishers began revising instructional materials, states and districts began developing transition plans, and a host of players began offering professional development to teachers. Although studying any of these or other efforts would provide information about how the system is responding to the CCSSM, in establishing a priority research agenda, we took into account existing research on which components of the system exert the most leverage on K–12 education. In particular, we identified the development and influence of the consortia assessments, and the development and selection of curriculum materials, as the most important targets for research on how the system is responding to the CCSSM. Here we include examining the extent to which having common standards has led to greater collaboration and economies of scale, as the common core theory of action predicts.

Also important, but of somewhat lower priority, are case studies of the transition process, as identifying strategies that appear to be effective across a variety of state and district contexts will help inform the implementation of the CCSSM and future sets of standards. Similarly, as curriculum materials are developed and revised to reflect the CCSSM, it will be important to analyze the most commonly used curriculum materials in terms of alignment with the standards and with the assessment frameworks.

There is no question that research in other key areas would provide a fuller picture of the influence of the CCSSM, as well as help the field understand the conditions under which these standards are and are not leading to the desired outcomes. Among the areas of interest, but considered lower priority for research are how other important components of the mathematics education system are responding to the CCSSM, including pre-service and alternative certification programs; professional development programs; institutions of higher education; and professional societies. (See Appendix E.)

• **What happens, and for whom, as a result?**
Research may determine that the mathematics education system is in fact changing to align with the CCSSM, but that is only part of the story. Early studies of impact on students in places where instruction is aligned with the CCSSM will provide important information, but effectiveness with early adopters may not predict broader impact. Research on a larger and more representative sample of classrooms, using a variety of outcome measures, will be needed to identify the conditions under which the CCSSM are effective, and for whom. Similarly, while it will take time for the earliest cohort of high school graduates to have experienced the CCSSM throughout their K–12 education, given the goal of preparing students for college/careers, research in this area is essential for testing the theory of action of the CCSSM. The key question is whether students whose K–12 learning opportunities and outcomes reflect the CCSSM are in fact well prepared for post-secondary education and careers. And over time, research on the extent to which there are improvements at scale on college and career readiness, as well as on key national and international K–12 assessments, will be an extremely high priority.

Case studies of how teachers interpret the CCSSM and the implications they see for their instruction, are also included in the priority research agenda, but are considered of somewhat lower priority. Similarly, periodic status studies of representative samples of teachers and their

teaching as they relate to the CCSSM would be helpful in assessing the influence of the standards, but are not deemed as high in priority as studies that explore the relationships between implementation of the CCSSM and student outcomes.

• **How can the CCSSM and future standards be improved?**
The priority research agenda includes studies that can inform revisions to the CCSSM, as well as development of future sets of standards. Included in this category are investigations of standards progressions that researchers believe are not adequately supported by prior research and/or where alternative progressions may be more effective. Similarly, studies to establish learning progressions for the standards for mathematical practice would be very informative, as little is known in this area.

## A. Case Studies

The large number of states adopting the CCSSM, and the major efforts underway to support their implementation, suggest a need for research to begin immediately to document the process, including the rationale for, and consequences of, the various actions being taken. The specific targets for case studies that emerged as priorities are the cross-state assessment consortia; efforts to revise/develop curriculum materials in response to the CCSSM; state/district responses to the CCSSM; and, as efforts to introduce and implement these standards proceed, teachers' responses to the CCSSM.

***Priority Case Study Focus #1: Development of the consortia assessments***
The two cross-state assessment consortia funded by the U. S. Department of Education are viewed as a priority for study because high-stakes assessments are known to be a major force influencing the nature and content of the curriculum students will experience. In addition, they represent a key domain in which the commonality of standards supports collaboration across states. How content ideas and practices are treated on the assessments will send strong messages, whether intended or not, about which content within the standards is most important. Consequently, it will be critical to understand how and how effectively the development of consortia assessments guards against an unintended "narrowing" of the curriculum. We suggest that case studies of the development of these assessments be carried out by "embedded researchers," who can document the process, describe the trade-offs that are considered, and convey the rationale for the various decisions. These case studies should focus on the following questions:

1. How are the CCSSM standards for mathematical content and mathematical practice, as well as the standards progressions, being interpreted by key decision-makers in the assessment consortia? What specifications for assessment design result from these interpretations? Do the tests strongly focus where the standards strongly focus?

2. How do various affordances and constraints influence the nature of the assessments: the purposes for which the assessments are being developed; current state of the field in assessment development; potential opportunities and benefits, as well as costs and constraints, of technology-enabled administration of assessments; and the diversity of

contexts of intended use, e.g., with students whose native language is other than English, with students who have varying access to technology?

3. In what ways and to what extent are the capacities and resources of collaborating states and other entities being leveraged in the work of the assessment consortia? What affordances and challenges arise in these efforts due to cross-state collaboration?

4. What other resources are the assessment consortia producing, and for what purposes? For any resources distributed prior to the release of the assessments themselves, what influences are these resources having on states and other parties that are accessing them?

***Priority Case Study Focus #2: Influences of the consortia assessments***
In 2014-15, the assessment consortia are due to release their products for use in state assessment and accountability systems. At that point, it is likely that the influence of the CCSSM will be strongly mediated by the assessments. We suggest that case studies conducted over the three- to five-year period after the release of the consortia assessments address the following questions:

1. How are states intending to use the assessments for accountability and decision-making purposes? Over time, what information do the assessments provide for these purposes? What are the accountability consequences? What decisions are informed by the assessments, with what consequences, for whom?

2. How are districts and schools planning to use the assessments for their accountability and decision-making purposes, and for formative and diagnostic purposes? Over time, what information do the assessments provide for these purposes? What are the accountability consequences? What decisions are informed by the assessments, with what consequences, for whom?

3. In what ways are curriculum development efforts and teacher development efforts influenced by the portrayal in the consortia assessments of the standards for mathematical content and practice, and the standards progressions, as well as by how the assessment results are being used by states, districts, and schools?

4. In what ways is the enacted curriculum influenced by the portrayal in the consortia assessments of the standards for mathematical content and practice, and the standards progressions, as well as by how the assessment results are being used by states, districts, and schools?

***Priority Case Study Focus #3: Curriculum materials development/revision process***
Textbooks/programs are a key leverage point in the system, as how they organize and present content exert a strong influence on the curriculum that students experience. Given the enormous market for curriculum materials that address the content of the CCSSM, publishers are already responding to the CCSSM. Consequently, understanding how and why curriculum materials are or are not developed/revised in response to the CCSSM is a priority for research.

Since some states are moving ahead quickly in implementing the CCSSM, it is likely that major curriculum materials publishers will respond by revising existing materials. Revisions may take various forms—e.g., moving topics into particular grade levels, re-sequencing topics within grade levels, modifying the mathematical approach for particular topics, and adding specific ties to the standards for mathematical practice. And there will also be efforts to develop new materials specifically aimed at the CCSSM.

In studying the curriculum development/revision process, it will be important to include a variety of materials (e.g., at the high school level those that are course-specific, and those that take an integrated approach), and to be strategic in the selection of mathematics content areas on which to focus. Choosing content topics that vary from the currently predominant approaches will be particularly telling, such as new content topics, or content topics that are approached, sequenced, or connected to other topics differently. Case studies of the revision/development process should address the following questions:

1. How are the CCSSM standards for mathematical content and mathematical practice, and the standards progressions, being interpreted by curriculum materials developers? What plans for revisions result from these interpretations? Do new or revised curricula focus strongly where the standards focus strongly? How are developers planning to address variations across states introduced by the option of including 15 percent state-specific standards?

2. What expertise and resources are developers using to inform their revisions to curriculum materials?

3. To what extent does the development/revision process take into account the needs of various subgroups of students and contexts of schooling?

4. What consideration is given in the development/revision process to providing enrichment/remediation opportunities for students whose progress differs from the expectations laid out in the CCSSM?

5. In what ways are curriculum developers revising the "educative" components in their materials intended to inform and provide professional learning opportunities to address the needs of teachers as they use the materials?

Some mathematics educators have expressed concern that widespread adoption of the CCSSM will lead to lack of innovation in curriculum materials, and in turn, diminished opportunity for the field to continue to learn about effective organization and sequencing of mathematics content for student learning. Similarly, there is concern that the CCSSM do not emphasize the use of technology for learning and doing mathematics to the extent necessary for college/career readiness. These kinds of concerns suggest a need for case study research to look across cases of the most widely used materials aimed at the CCSSM, and to compare them with efforts that are not attempting to address the CCSSM, addressing additional questions, including:

6. What similarities and differences in content organization and presentation exist across curriculum materials intended to address the CCSSM? What accounts for these similarities and differences?

7. When addressing the CCSSM, what opportunities, if any, do curriculum materials developers have for innovation, including the integration of technology? What constraints, if any, restrict innovation?

8. When addressing mathematics content not included in the CCSSM, what opportunities, if any, do curriculum materials developers exercise opportunities for innovation, including the integration of technology? To what extent is the inclusion of state-specific standards (the 15 percent allowance) providing opportunities for innovation? What constraints, if any, restrict innovation?

***Priority Case Study Focus #4: State/district responses to the CCSSM***

Although 40+ states have adopted the same set of mathematics standards, individual states and the districts within them face very different challenges in transitioning to full implementation of the CCSSM. Studying how and why states/districts are responding to the CCSSM (including choosing not to adopt them) is an important part of understanding their influence. The proposed research agenda suggests case studies of states and districts, including a set of locales that vary in demographics; policy context; commitment to the CCSSM; and history with content standards, including how similar the CCSSM are to their most recent standards.

Some states and districts have made a strong and immediate commitment to implement the CCSSM at scale, while others intend to phase in the CCSSM over time. In addition to differences in phases-in approaches, there are differences in perspectives regarding how much change the CCSSM represent from current standards. The authors of the standards have indicated that the CCSSM convey a major shift in the focus of mathematics education in the United States. However, there are signs that some states, some observers, and some sectors in the education system see the implementation of the CCSSM as entailing only minor changes. In case studies of state/district transitions will be critical, considering both content that appears fairly similar and content that seems quite different from previous standards, as well as both mathematical practices and standards progressions. Additionally, it will be important to understand the rationale for any shifts in organization at the high school level (e.g., from course-specific to integrated pathways, or vice versa) in light of the CCSSM.

Different states will have widely varying resources and incentives to support implementation of the CCSSM, federal Race to the Top awards for some states and not others being a primary example. Across states and districts, the existing leadership and capacity, and the ability to develop leadership and capacity will vary considerably, likely leading to differences in how, and how well, they are able to implement the CCSSM. Case studies of states and districts in transition, ideally conducted by researchers embedded in the process, will provide a great deal of information about how the CCSSM are influencing mathematics education.

a. Initial Case Studies of Adopting States/Districts

Initially, the following questions should be addressed in a variety of jurisdictions which are planning to implement the CCSSM:

1. What policy levers (e.g., mandates, incentives) are states using to influence which parts of the system (e.g., curriculum, teacher development, assessment) and at what level (state, local, classroom)? How do the states differ, and why are they taking different paths?

2. How do broader opportunities and constraints, in particular cross-state collaborations, cross-district collaborations, and federal initiatives, influence plans for supporting implementation of the CCSSM?

3. How are states/districts modifying policies and programs to support implementation of the CCSSM across the range of contexts they include?

4. How are key stakeholders (policy makers, leaders in business and industry, higher education, non-governmental organizations, teacher unions, parents, and the general public) exerting influence on plans for CCSSM implementation?

b. On-going Case Studies of Adopting States/Districts

Over time, following the transition to the CCSSM in these selected places, and in others that may emerge as experiencing particular successes or challenges, case studies will remain among the priorities for research, addressing the following questions:

1. How do specific policies, programs, and resources intended to support implementation of the CCSSM play out? How do successes and challenges of implementation, in turn, influence these policies, programs, and resources?

2. What other policies, programs, resources, and contextual factors influence implementation of the CCSSM, and in what ways?

3. How do broader opportunities and constraints, in particular cross-state collaborations, cross-district collaborations, federal initiatives, and programs and tools offered by third-party entities influence implementation of the CCSSM over time?

4. How are key stakeholders (policy makers, leaders in business and industry, higher education, non-governmental organizations, teacher unions, parents, and the general public) exerting influence on CCSSM implementation over time?

5. What organizational systems are supporting implementation of the CCSSM? Which players are involved in implementation of the CCSSM, and how do they compare to the players involved in mathematics education improvement efforts prior to the CCSSM?

6. What is the depth and breadth of penetration of the CCSSM within the state/district system? What parts of mathematics education in the state/district are affected and in what ways? What parts are not affected? With what consequences?

7. Within the state/district, what variations in implementation of the CCSSM are evident? What accounts for those variations? For whom do these variations have important consequences?

8. How are districts, schools, and teachers (a) helping students catch up when their progress falls behind the expectations of the CCSSM; and (b) providing enrichment opportunities for students who are performing above expectations?

9. How are states/districts/schools responding to challenges associated with more rigorous standards, e.g., increased drop-out rates, low passing rates for particular subgroups of students on consequential assessments?

10. What strategies appear to be effective across a variety of state and district contexts?

c. Case Studies of Non-adopting States

Although the CCSSM have been adopted in the great majority of states, there are states that have chosen not to adopt, and the possibility remains that some states that initially adopted the CCSSM may change their commitment over time. In understanding the influence of the CCSSM, how mathematics education evolves in non-adopting states provide an important point of contrast. At the same time, the CCSSM are anticipated to influence the mathematics education system nationally in ways that are likely to have important effects even in non-adopting states. Key questions to address in case studies of selected non-adopting states are:

1. Why did the state choose not to adopt the CCSSM?

2. How do the state's mathematics standards compare to the CCSSM? What similarities and differences between the state's standards and the CCSSM are considered important and why?

3. What policies, programs, and resources within the state are intended to support mathematics education improvement in the state? How do these play out?

4. How are key stakeholders (policy makers, leaders in business and industry, higher education, non-governmental organizations, teacher unions, parents, and the general public) exerting influence on improvement efforts over time?

5. What broader influences of the CCSSM initiative affect non-adopting states, and in what ways?

***Priority Case Study Focus #5: Teacher responses to the CCSSM***

Unless the influence of the CCSSM ultimately reaches teachers of mathematics, any other influences will mean little for most students' learning opportunities. Since teachers' knowledge, interpretations, self-efficacy, beliefs, dispositions, and skill, as well as their specific intentions and plans, affect what transpires in classrooms, it is critical to understand how teachers respond to the CCSSM, and what kinds of classroom learning opportunities for their students result. At the same time, it is important to recognize that teachers are not likely to be influenced directly by standards, but rather by a combination of many sources that translate and communicate implications, intended or not, of the standards. Case studies of teachers' responses to the CCSSM should address the questions below, ensuring that in aggregate these studies represent teachers of varying backgrounds and characteristics; working in a variety of school contexts and serving different student subgroups, with varying levels of collective effort in relation to implementing the CCSSM.

1. What opportunities do teachers have to learn about the CCSSM and their implementation? What messages do teachers take from these opportunities? What do teachers see as the implications for their further professional learning?

2. What implications do teachers see for their mathematics instruction? What aspects of their mathematics instruction do they see as validated by the CCSSM, and what aspects do they consider in need of change based on the CCSSM? Do teachers view these changes as positive, negative, some mixture of the two, or the latest in a long line of fleeting "reforms"? Why?

3. What curriculum materials and resources, including textbooks, supplemental materials, assessment tools, and instructional technologies do teachers use to implement changes in their mathematics teaching in relation to the CCSSM? Why do they use these particular materials/resources, and with what effects? What available materials/resources do teachers not use and why?

4. Over time, to what extent and in what ways do teachers perceive their practice aligning with the expectations of the CCSSM standards for content and practice, and the standards progressions? How do observers' views of alignment compare and contrast with teachers' perceptions?

## B. Relational Studies

If standards are to make a difference in students' opportunities to learn important and useful mathematics, various parts of the system need to align with those standards and work in concert. Research on the influence of the CCSSM requires studies to understand the extent to which implementation efforts result in alignment/non-alignment throughout the system, and the downstream consequences of those variations in alignment.

Three types of relational studies are recommended for research to understand the influence of the CCSSM: (1) proofs of concept, (2) broader studies of conditions of effectiveness, and (3)

experiments to determine whether interventions can produce conditions of effectiveness in various contexts. The purposes for these three types of studies are different and complementary. Proofs of concept are generally opportunistic, or conducted under fairly special circumstances, to establish the viability of a particular relationship. Broader studies of the conditions of effectiveness extend beyond special circumstances to examine the conditions under which particular relationships exist, and for whom. These studies can also offer explanations of why and how particular conditions result in various outcomes. Finally, experiments, or quasi-experiments, are useful for establishing whether creating particular conditions in fact produces the outcomes of interest, and provides for further study regarding for whom these relationships hold. Studies of each type are recommended to address several critical relationships.

***Priority Relational Study Focus #1: Relationship between the enacted curriculum and K–12 student outcomes***

Studies of the relationship between the classroom enactment of learning experiences aligned with the CCSSM and students' achievement of the designated learning goals are a key priority in the proposed research agenda. A body of studies would need to be conducted to examine this relationship at different grade levels; for different standards for mathematical content and practice; with students of various backgrounds; and with students who experience different types of programs (e.g., course-specific and integrated mathematics programs, programs with varying degrees of tracking). In particular, it will be important to distinguish between persistent differences in achievement due to different instructional experiences, versus differences in achievement due to differential effectiveness of the same instructional experiences for various groups of students. In addition, this body of studies would collectively need to address a range of student outcomes of importance, including not only achievement of the standards for mathematical content and practice, but also dispositions toward the study and use of mathematics; and interest in, and aspirations for, STEM careers. These studies should address the following questions, attending to possible differences across various student subgroups and contexts:

1. What outcomes result when the enacted curriculum students experience is closely aligned with the CCSSM?

2. What outcomes result when the enacted curriculum students experience is aligned with the CCSSM in various ways and to varying degrees? How can these outcomes be explained by students' classroom learning experiences?

3. What instructional and contextual factors mediate relationships between alignment of the enacted curriculum with the CCSSM and student outcomes? How and why do these factors enhance or inhibit student outcomes?

4. What student factors, including experiences they have outside of the school environment, mediate relationships between alignment of the enacted curriculum with the CCSSM and student outcomes? How and why do these factors influence student outcomes?

5. To what extent do students whose progress in achieving the CCSSM falls behind expectations have remediation and re-entry opportunities that allow them to attain the learning expectations of CCSSM in order to enter post-secondary education, careers, or career preparation successfully? What student factors mediate this relationship? What accounts for variability in the effectiveness of remediation and re-entry opportunities?

6. To what extent do students whose progress exceeds the expectations of the CCSSM have enrichment opportunities that allow them to pursue mathematics study in greater depth and breadth? What school, teacher, and student factors mediate this relationship? What accounts for variability in the effectiveness of enrichment opportunities?

***Priority Relational Study Focus #2: Relationship among the enacted K–12 curriculum, the achieved K–12 curriculum, and college/career readiness***

As noted earlier, the CCSSM are intended to specify the mathematical content understandings and practices considered fundamental for K–12 students' preparation for college and careers. Studies addressing this relationship should be a priority once assessments are in place to document students' achievement of the learning expectations of the CCSSM and sufficient time has passed for students completing their K–12 education to have experienced mathematics programs influenced by the CCSSM.

Studies of the relationship of the enacted and achieved K–12 curriculum and students' college and career readiness should also account for other aspects of readiness that might be affected by implementation of the CCSSM, such as readiness to use various technologies, and to learn new technologies, that are important for further education and career preparation and success. Priority studies of the relationship between students' K–12 learning experiences, achievement of the CCSSM learning expectations, and post-secondary outcomes should address the following questions, in each case attending to possible differences across student subgroups and contexts:

1. To what extent do students whose K–12 learning opportunities and outcomes indicate attainment of the learning expectations of the CCSSM (a) enter post-secondary education ready for credit-bearing mathematics and other STEM coursework, (b) successfully enter careers? What school, teacher, and other student factors mediate these relationships? What contextual factors of post-secondary institutions mediate these relationships?

2. How do students whose K–12 learning opportunities and outcomes reflect differences from the learning expectations of the CCSSM fare in college mathematics and other STEM coursework, or careers requiring mathematical knowledge?

***Priority Relational Study Focus #3: Relationship between consortia assessment results and other measures, i.e., validation of consortia assessments***

Historically, student assessments, especially when they have high stakes attached, are a major lever in determining the content that is emphasized in K–12 mathematics education. The assessments produced by the two cross-state consortia are anticipated to be primary sources of

information about students' attainment of the CCSSM, informing judgments and decisions about students, teachers, schools, programs, and policies. Consequently it is important to investigate the validity of expected and actual uses of results from the consortia assessments.

These validation studies are considered relational because they will examine the relationship between results of consortia assessments (and the judgments and decisions that are made based on those results,) and results obtained from other measures, including other desired student outcomes that are not measured on the consortia assessments. First, studies are needed to determine whether the consortia assessment results are consistent with results obtained from more in-depth measures than are possible to administer on a very large scale. Second, results on long-standing measures, such as NAEP, should be compared to the results of the consortia assessments to determine if trends shown on the consortia assessments are seen in these other measures as well. Finally, investigations are needed of the extent to which results on the consortia assessments predict readiness for further study of K–12 mathematics, and for college/careers. Studies are recommended to answer the following questions:

1. Throughout the K–12 grades, how do the consortia assessment results compare to results from more in-depth measures of students' progress in achieving the standards for mathematical content and practice? Are formative and summative judgments based on the consortia assessment results supported by results of more in-depth measures? How, if at all, do these comparisons differ across subgroups of students and students educated in different contexts?

2. How do trends over time on the consortia assessments compare to established measures of mathematics achievement, such as the National Assessment of Educational Progress?

3. How does the content of high school assessments compare to higher education STEM faculties' expectations for college readiness and employers' expectations for career readiness? At high school graduation, how do the consortia assessment results compare to other measures of students' achievement of the standards for mathematical content and practice? Are judgments based on the consortia assessment results (e.g., remedial vs. credit-bearing college course placement, qualification for careers) supported by results from more in-depth measures? How, if at all, do these comparisons differ across subgroups of students and students educated in different kinds of contexts?

4. How are the consortia assessment results being used in evaluating teacher performance or progress, school status or progress, and program or policy effectiveness? Are judgments based on the consortia assessments supported by other evidence?

***Priority Relational Study Focus #4: Influences on the enacted curriculum***

The intent of the CCSSM is to ensure that all students in the United States, regardless of where they happen to go to school, have the opportunity to engage with a core set of key mathematics ideas and practices, sequenced and connected in a meaningful way. The CCSSM do not

prescribe how to go about enacting classroom learning experiences, or how to go about ensuring that the standards are enacted at scale in classrooms. The enacted mathematics curriculum, made up of elements described previously, results from the interplay of a wide range of teacher factors, teacher professional learning opportunities, and school factors, combined with available curriculum materials and resources, and assessment tools. Student characteristics, too, play a key role in constructing the enacted curriculum.

Studies of these influences on the enacted curriculum should be conducted across grade levels, and in a wide range of contexts. Additionally, they should examine research-established aspects of classroom learning experiences that may not be addressed by the CCSSM, but are known to relate to student learning. To gain a comprehensive picture of the enacted curriculum, these studies must also consider a variety of mathematical content, standards progressions, and mathematical practices. Results from these studies would shed light on the kinds of learning opportunities students are encountering, aligned or not aligned with the CCSSM, and would provide evidence to explain variations. Research should address the following questions:

1. How do state and district policies, programs, resources and contexts affect the enacted curriculum in classrooms?

2. How do characteristics of curriculum materials, including both student materials and materials providing guidance and educative features for teachers, affect the enacted curriculum?

3. How do teacher background factors (e.g., knowledge, skills, beliefs, dispositions), interpretations of the CCSSM, and expectations for student learning more generally, affect the enacted curriculum in their classrooms?

4. How do teachers' opportunities to learn about (a) the CCSSM, and (b) how to address those expectations, affect the enacted curriculum in their classrooms?

5. How, if at all, does the enacted curriculum that students experience differ across various subgroups of students and in different contexts? What teacher background, teacher opportunity, and school factors explain these variations?

## C. Status Studies

The CCSSM are intended to improve the quality of mathematics education at scale. Consequently, understanding the influence of the CCSSM needs to include studies of the extent to which the system is improving, and for whom. The status studies that have been identified as priorities provide a picture of key aspects of the system. They would further allow for investigation of trends over time, and disaggregation so that comparisons can be made across subgroups and contexts.

Several types of status studies are recommended to shed light on the influence of the CCSSM. First, the United States already invests in large-scale, representative data collection efforts (e.g.,

National Assessment of Educational Progress) that can yield information to suggest ways that the CCSSM may, or may not, be having an impact on the mathematics education system nationally. Second, since these large data collection efforts may not have historically addressed certain indicators of interest, e.g., in relation to the standards for mathematical practice, items could be piggy-backed onto existing efforts to collect these data. Third, for some areas of interest, such as the prevalence and quality with which the CCSSM standards progressions are addressed in curriculum materials or in classrooms, there may not be existing national efforts that lend themselves to the needed data collection, so new efforts would be necessary.

***Priority Status Study Focus #1: K–12 students' interests, aspirations, and achievement***
Many stakeholders will consider student achievement outcomes the bottom line for judging the influence of the CCSSM. Undoubtedly, the results of consortia assessments or alternatives that states employ for standardized testing will receive considerable attention. Also, U.S. students' performance on national assessments (e.g. National Assessments of Educational Progress (NAEP)) and international assessments (e.g., Trends in Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA)), will remain important for gauging progress in student preparation over time and in relation to other nations. It is not clear, as yet, that any of these assessments will provide evidence regarding students' success or struggles with specific features of the CCSSM, such as advancement along the standards progressions or growth in understanding and use of mathematical practices; other assessments may be needed to conduct status studies of these key features.

In addition to achievement, a number of other student outcomes are proposed as priorities for status studies throughout the K–12 grades, including dispositions toward the study and use of mathematics, confidence in mathematics knowledge and abilities, and interest in mathematics and other STEM fields. Advanced course taking and success have also been important metrics for judging the quality of mathematics education, so we recommend measuring enrollment in Advanced Placement, advanced International Baccalaureate, and dual enrollment college-level mathematics as the implementation of the CCSSM proceeds.

A very strong priority for investigating the status of student outcomes is to examine results for different subgroups of students and different contexts of schooling. It is also important to disaggregate results by grade level and content domains, as students' success and challenges are likely to vary along these dimensions. Key research questions in relation to K–12 student outcomes are:

1. Across grades K–12, to what extent are students achieving various levels of mastery of the standards for mathematical content and practice? What variations in achievement are evident across student groups and contexts of schooling?

2. How many and which students are enrolling in, and succeeding in, advanced mathematics courses in high school? To what extent are students who are prepared for study in advanced mathematics courses either not enrolling, or not succeeding, in these courses?

3. What is the nature and distribution of students' dispositions toward mathematics; confidence in their mathematics abilities; and interest in, and aspirations for, STEM study and careers? What differences are evident for various student subgroups/contexts?

***Priority Status Study Focus #2: College/career readiness***

The CCSSM describe the mathematical content understandings and practices that have been proposed as key to K–12 students' preparation for success in college and careers. Over time, one measure of success of the CCSSM initiative will be evidence that high school graduates are in fact increasingly becoming prepared for the mathematical demands of their post-secondary education and work. And in particular, there is widespread interest in the STEM "pipeline," ensuring that a larger and broader pool of students have interest in, and preparation for, careers in STEM fields. Status studies of students' college and career readiness should address the following questions, in each case including investigating variations across subgroups of students from varying K–12 educational contexts:

1. To what extent are students entering college prepared for placement and success in credit-bearing mathematics courses?

2. To what extent are students in college pursuing and succeeding in mathematics and other STEM majors?

3. To what extent are students entering careers prepared for the mathematics demands of their work?

***Priority Status Study Focus #3: Analysis of curriculum materials and accompanying guidance for teachers***

As noted earlier, mathematics curriculum materials exert a strong influence on K–12 students' learning experiences. A wide variety of curriculum materials have historically been available in the United States, including those that were developed initially to reflect the vision of the NCTM standards (NCTM 1989, 2000), and they have organized and presented content in substantially different ways. Curriculum materials developers have had little time to prepare for widespread adoption of the CCSSM, and they are likely to have different interpretations of the implications for particular content areas. Consequently, revisions of existing curriculum materials and the accompanying guidance for teachers are likely to result in variable alignment with the CCSSM both within and across curriculum materials. New materials will be developed over time and, given market forces, it is likely the CCSSM will have a strong influence on these materials as well. Monitoring the extent and nature of the alignment of a variety of curriculum materials with the CCSSM, and with the consortia assessment frameworks and tests, will be revealing regarding the potential reach of the standards by addressing the following questions for a variety of materials, including the most commonly used supplemental or replacement materials that may be used in place of, or alongside, full curriculum materials programs:

1. To what extent are the standards for mathematical content at various grade levels evident in the materials, and how well do they reflect the intended rigor and depth of the CCSSM?

2. To what extent does the approach to, and sequence of, content in the materials reflect the standards progressions of the CCSSM?

3. How and to what extent are the standards for mathematical practice evident in the materials, and integrated with the standards for mathematical content?

4. To what extent are materials including content addressed by individual states as part of their 15 percent allowance?

5. How much and what kinds of support are provided for teachers about how to address the key features of the CCSSM, and in particular how to assist students who are having difficulty with achieving the grade-specific or high school level standards, as well as those who would benefit from enrichment?

***Priority Status Study Focus #4: Alignment of the enacted curriculum with the CCSSM***

The ultimate aim of the CCSSM is to improve student outcomes, and it is through the learning experiences enacted in their mathematics classrooms that most students will have opportunities, or not, to achieve the expectations of the standards. Studies of the enacted curriculum should focus on a variety of elements, including: the sequence and connectedness of content; the mathematical tasks students encounter; the demands of solving and making sense of those tasks; the material, technological, and social resources students have to do so; and the assessment of student learning for formative and summative purposes.

We view studying the enacted curriculum as a bridge for understanding the connection, or lack of connection, between the channels of influence described in the NRC framework and the extent and variability in intended and unintended student outcomes. Status studies of the enacted curriculum are recommended to answer a set of questions parallel to those for curriculum materials, recognizing that the curriculum materials being used are only part of what contributes to the enacted curriculum. It is particularly important to investigate the extent to which variation in alignment to the CCSSM across classrooms results in different learning opportunities for various student subgroups. Studies of the enacted curriculum should address the following questions, in each case exploring variations across student groups and contexts:

1. To what extent are the standards for mathematical content at the K–8 grade level, or conceptual category in high school, evident in the enacted curriculum with the intended focus, rigor, and depth of the CCSSM? What variations in enactment, including appropriate differentiation, are evident across student groups and contexts of schooling?

2. To what extent does the approach to and sequence of content in the enacted curriculum reflect the standards progressions of the CCSSM?

3. How and to what extent are the standards for mathematical practice evident in the enacted curriculum, and integrated with the standards for mathematical content?

## D. Studies to Improve the Standards

In addition to understanding the influence of the current version of the CCSSM, the implementation of this set of standards provides an opportunity to generate knowledge that can inform revisions to the CCSSM, as well as development of future sets of standards. Investigations for this purpose would focus on the theoretical assumptions upon which the CCSSM themselves are based, and the ways in which revisions to the CCSSM may take into account emerging research. For example, the notion of developing deep student understanding of key ideas over time is central to the CCSSM. However, even though the standards progressions included in the CCSSM were intended to be based on evidence of learning along particular content trajectories, and validated to the extent that the evidence could provide such support, the authors have indicated that the research base was very thin in some areas. As a result, in many instances the standards progressions are hypothesized rather than empirically-supported learning progressions.

Research efforts should capitalize on the fact that assessments, including the consortia assessments, are being designed to test student understanding along the trajectories of these standards progressions. Given that large numbers of students will take the same assessments, it will be possible to assess the validity of the hypothesized learning progressions, and to test the efficacy of alternative curricular and instructional approaches to support learning along these progressions. Alternative hypothetical learning progressions that researchers may generate should also be tested, which may entail developing and implementing alternative instructional materials as well as additional assessment items. Results from research of this kind can then be incorporated into revised standards progressions. Similarly, there may be areas where student performance falls particularly short of expectations and/or where teachers indicate something is just not working, even when the standards are implemented as intended. Such cases would indicate a need to rethink the standards progressions, including the grade placement of particular ideas.

The CCSSM do not, as yet, provide progressions of understanding for the standards for mathematical practice that would clearly look different at various grade levels. Research that hypothesizes and investigates progressions for the standards for mathematical practice should inform revisions to the CCSSM that provide greater guidance than is currently available for addressing this critical feature of the standards.

Another important area for research relates to the application of the standards for mathematical practice in instruction focused on the content standards, which may be more readily accomplished in some content domains than others. Research to illuminate how to accomplish this integration, and how it may be different or similar from one content domain to another, will support revisions to the CCSSM that could provide a more nuanced presentation of the standards for mathematical practice.

Given that the CCSSM initiative is intended to improve college and career readiness, research to support revisions to the standards needs to go beyond the 12th grade. It is not only a matter of whether specific content is part of the K–12 progression, but whether achieving the expectations

of that progression actually ends in college and career readiness. Finally, whether focused on K–12 or post-secondary outcomes, investigations designed to provide empirical evidence for the CCSSM should sample a range of locales and diverse groups of students to ensure that conclusions are representative across contexts and subgroups.

## METHODOLOGICAL CONSIDERATIONS

Implementation of the suggested research agenda has the potential to generate a wealth of knowledge about the influence of the Common Core State Standards for Mathematics. Whether or not that potential is realized depends not only on the quality of individual studies, but also on the extent to which the knowledge that is generated can be aggregated across studies to provide a comprehensive picture. The following recommendations are intended to help ensure systematic cumulation of knowledge in the field, both specifically in regard to the influence of the CCSSM and, we believe, more generally as well.

**• Theories of action should be used to provide structure for a set of studies.**
Specification of theories of action describing hypothesized pathways of influence of the CCSSM would help guide the design and interpretation of research (NCTM Research Committee, 2010; Weiss, 1997). Conducting research to investigate the various links along the various pathways of influence provides the means to amass chains of empirical evidence. In this way, sets of studies examining impacts and effects within different parts of the system can be combined to trace the nature and conditions of influence of the standards over time. Other studies could examine influence via a longitudinal, dynamic view, to follow hypothesized pathways of influence within a particular context conducted over longer periods of time. As the evidentiary base grows, the theory of action should be revisited both to: (1) synthesize knowledge (what has been learned about the relationships and pathways of influence the model posits and what still needs to be shored up through additional study), and (2) refine the model where evidence suggests it is under-specified or incorrect.

**• A data infrastructure needs to be created and managed.**
The widespread adoption of the CCSSM offers potential for research within and across many contexts, and on a large scale, drawing on comparable data. This potential can be realized only if a well-conceptualized, broadly accessible infrastructure is created for collecting, combining, and sharing data. Much more than a clearinghouse for data or a monitoring mechanism, the envisioned infrastructure would support decisions about directions and priorities for research. Tying both data and the results of studies to a specified theory of action as suggested above, the data infrastructure could serve to identify research needed to test promising approaches in new and diverse contexts; to examine why hypothesized relationships are or are not evident at various times and in various places; and to prompt studies that are needed to track changes over time once pre-requisite conditions or contingencies appear to be in place. Developing and managing a data infrastructure serving these functions would enable cumulation of research knowledge that can promote broader understanding of what policies, programs, and practices (in this case related to the implementations of the CCSSM) are and are not effective, for whom, and under what conditions.

**• Common indicators of alignment need to be defined and used.**
In order to cumulate knowledge about the influence of standards, it is imperative that the field come to agreement about what distinguishes meaningful alignment with the CCSSM from superficial alignment and non-alignment. These indicators will be essential for assessing the extent of influence of the CCSSM on any part of the system. They will also be crucial for tracing influence between and among parts of the system, as conclusions about causal links and other dependencies need to be based on evidence that alignment with the standards in one part of the system is related to alignment in another.

- **Existing high quality instruments, and new instruments to be developed, need to be used more systematically in order for the field to understand the influence of the CCSSM.**

Research on the influence of the CCSSM requires instruments to measure the nature and extent of alignment of various components of the mathematics education system, for example, characterizing curriculum materials in terms of the aspects of the standards that are and are not evident. A variety of instruments for studying alignment with standards have been developed over the past 20 years. (See, for example, Council of Chief State School Officers (CCSSO) Surveys of Enacted Curriculum (SEC) Collaborative Project, 2005; Webb, 1997.) However, because these tools were developed before the CCSSM, they do not adequately address critical features such as the standards progressions or standards for mathematical practice. The revision/development and validation of the tools needed to pursue priority research questions on the CCSSM should itself be a priority for the field, perhaps using Race to the Top states and other early adopters as sites for this work. At the same time, the CCSSM may result in unintended consequences, e.g., decreased innovation in curriculum materials. These potential influences, too, must be accurately measured to be understood. Using sound measurement tools (existing or newly-developed), studies that employ the same instruments can be most easily compared and combined to examine similarities and differences in influence according to variations in interventions, contextual factors, target populations, and so on. At the same time, studies of the same relationship that employ different high quality instruments can provide a test of the robustness of findings, ensuring that they are not dependent on the idiosyncrasies of any particular measure.

**• Studies need to distinguish between alignment and quality.**
The CCSSM can be viewed as a set of hypotheses—if the system responds to the standards and mathematics education is provided as the standards expect, then improved student outcomes will result. At the same time, these standards do not encapsulate all that is known or hypothesized to be effective in improving the mathematics education system, so alignment with the standards cannot be equated with effectiveness. Rather, the influence of the CCSSM on teaching and learning clearly depends on factors that are not addressed in the standards. For example, two sets of curriculum materials, judged equally aligned with the standards for content and mathematical practice called for in the CCSSM, may have very different influences on classroom instruction and student learning because of other characteristics, such as educative features for teachers or incorporation of formative assessment techniques. In addition to attending to indicators of alignment, research on the influence of standards should consider other factors known to relate to effectiveness, as well as additional factors that may explain differential effectiveness. For informing future efforts, what turn out to be the strongest features of quality might be made explicit in plans for implementing standards.

**• Planned studies need to be sensitive to the timeline of events.**
In planning research on the CCSSM, it is important to consider the timeframe and likelihood of influence. In jurisdictions that are moving quickly ahead with implementation of the CCSSM, including states that have received Race to the Top funding, it will be important to conduct research in the near term to investigate the relationship between the alignment of the enacted curriculum with the CCSSM and student outcomes. In contrast, it makes little sense to conduct a national observation study of the extent of classroom alignment with the CCSSM before aligned curriculum materials are readily available and efforts to implement the standards are well underway. Staying abreast of decisions that could alter the sequence of implementation phases is essential in executing relevant, timely, and informative research, especially because of the abundance of forces (federal officials, state officials, superintendents, teachers, the public, etc.) that can impact roll-out designs.

- **Phenomena need to be examined both "up close" and "at scale," although not necessarily in the same studies or in that order.**

To build a robust knowledge base, research on the influence of the CCSSM should use a variety of approaches, including qualitative, quantitative, and mixed method studies. Research needs to include both "at scale" studies to document the extent of alignment of key components of the system with the CCSSM and "up close" studies to understand how that alignment/non-alignment came about, to explain differences in extent of alignment, and to investigate consequences. At-scale and up-close studies may be productively juxtaposed in a variety of ways. An at-scale study may uncover widely varying alignment of a key system component (e.g., adopted curriculum materials) across states, or across districts within a state. Up-close studies might follow to investigate the interpretations and factors that led to differences in alignment. Other up-close studies may examine important outcomes, such as teacher knowledge or classroom practice, to gain insight into the relationship between variations in alignment and possible effects on these downstream outcomes. Alternatively, an up-close study may reveal a particularly powerful influence on alignment in one or more contexts (e.g., the use of a specific, widely available tool for curriculum materials review) that can subsequently be investigated in at-scale studies to determine its use and importance more broadly.

**• Research needs to attend to context as well as content.**
Although it is not feasible to conduct research in every classroom in every community in the United States, it is vital that studies are conducted in a variety of contexts. In particular, given the vast intended reach of the CCSSM, research is needed to understand the influence of the standards in states where the CCSSM are fairly similar to and quite different from previous standards; in states with different policy contexts, in particular in relation to centralized versus local control; in different community types; in schools and classrooms with varying student demographics; and with teachers of different content backgrounds and years of experience. Similarly, although it is not necessary to conduct research on every content standard at every grade, it is important to consider multiple content areas in different grades to test similarities and differences in influence that may depend on nuances of the content itself, or its historical place in the U.S. curriculum. Additionally, studies are needed that address standards progressions across grades, to examine how this key feature of the CCSSM plays out at various levels of the system.

**• Threats to validity need to be addressed through complementary studies.**
In social science, there is no such thing as a perfect study, one that avoids all threats to both internal and external validity. A stronger knowledge base will result from sets of studies that together address the major threats to validity for the priority research questions, so that the unaddressed threats in some studies are the addressed threats in others. (In particular, although people who are working to implement the CCSSM can and should study the effectiveness of their efforts, it is important that key relationships also be investigated by people who "have no dog in the fight.") By acknowledging weaknesses and their possible implications in publications, authors can help ensure that other studies can directly address those weaknesses through alternative designs. It is the complementary nature of research approaches that yields the strongest empirical support for knowledge claims.

**• Research needs to consider issues of attribution.**
To some extent, research that compares and contrasts efforts to improve student mathematical knowledge, and thus college and career readiness, in states that have and have not adopted the CCSSM will be helpful in understanding the influence of these standards. At the same time, to the extent that most publishers revise curriculum materials, and professional development and other efforts focus on supporting implementation of the CCSSM, it will be difficult to find appropriate comparison groups. If the CCSSM affect resources and programs that are used in both adopting and non-adopting states, comparisons between these two groups of states will be limited in their usefulness for establishing attribution of influences on student learning experiences and outcomes.

**• Research that applies different theoretical and conceptual frames is key to cumulating knowledge.**
The knowledge generated within a field of research is strengthened when studies of the same phenomena, or related phenomena, can be combined and compared. Pursuing a common research agenda provides increased opportunity to cumulate knowledge. Fields of research are also strengthened by the development, application, and testing of different theoretical and conceptual frames that shape studies and provide a basis for interpreting results. The pursuit of this priority research agenda must remain receptive to contributions from researchers bringing various theoretical and conceptual stances to their empirical work. At the same time, researchers must consider all theoretical and conceptual stances open to consideration, critique, and empirical examination.

**• Research is an essential component of "engineering for effectiveness."**
Given that education is enormously complex, with a huge number of variables that could make a difference in the implementation of the CCSSM in different contexts, the notion of engineering for effectiveness is helpful, where "education is treated as an organizational system that seeks, and is expected, to improve continuously" (Confrey & Maloney, 2011). The idea of a cycle of discovery (National Science Foundation, 2010) is also helpful in thinking about research on the influence of the CCSSM. Results of studies conducted in best case situations, on samples of convenience, or on other non-representative samples, can help identify hypotheses that can subsequently be tested with representative samples. Alternatively, larger but less intensive studies conducted with representative samples can identify patterns of influence, supporting more in-depth investigations to seek possible explanations for those patterns—what works, for

whom, under what conditions. In either case, in a continuous improvement model, research on the influence of the CCSSM would identify actions, conditions, and resources that support implementation; interventions would be designed accordingly, and in turn, studied.

## SUMMARY AND IMPLICATIONS

This report describes a priority research agenda for studying the influence of the CCSSM, developed with substantial input from mathematics education and policy researchers. It recommends research using a variety of approaches, including in-depth case studies to understand how key components of the system are changing in response to the CCSSM; status studies to determine the extent to which system components are becoming aligned with the CCSSM; and studies to explore the consequences, both positive and negative, of the CCSSM initiative on mathematics teaching and on a variety of student outcomes, K–12 and beyond. The priority research agenda also includes some preliminary ideas for generating knowledge to refine the standards over time, and includes a discussion of methodological considerations to help ensure the quality and rigor of individual studies, and the steady cumulation of knowledge.

The priority research agenda, while not comprehensive, is nevertheless an ambitious one. Implementing it will take a long-term commitment on the part of one or more funders. It will also take the energy and talents of researchers with a variety of backgrounds and interests working in a complementary fashion, building on one another's efforts. We believe that such a coordinated research enterprise is warranted in order to generate knowledge that can be used to improve this and future efforts to develop and implement standards.

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# Appendix A

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# Appendix B

## Other Research Areas of Interest for Understanding the Influence of the CCSSM

Given their widespread adoption, the CCSSM are likely to influence virtually every component of the mathematics education system in the United States. The priority research agenda suggests studies in a subset of areas that were considered particularly important. If resources are available, investigations in other key areas would provide a fuller understanding of the influence of the CCSSM, knowledge that would be useful in learning about implementation of these standards at scale, and the design and implementation of future standards.

**Teacher Preparation**

- To what extent and in what ways are mathematics/mathematics education classes in pre-service and alternative teacher certification programs aligned with the content and mathematical practices specified in the CCSSM? What accounts for differences in extent of alignment?
- What is the relationship between alignment of teacher preparation programs and: (a) new teachers' knowledge, dispositions, and skills for teaching the CCSSM; (b) their mathematics teaching; and (c) student outcomes? What explains/mediates these relationships?

**Teacher Professional Development**

- To what extent and in what ways are professional development materials, courses, workshops, and school-based programs such as professional learning communities aligned with the CCSSM? What accounts for differences in extent of alignment?
- How effective are professional development programs in enhancing teachers' knowledge and skills; improving their mathematics teaching; and improving student outcomes? What explains/mediates these relationships in various contexts and for teachers serving students from various subpopulations?

**Institutions of Higher Education**

- To what extent are the CCSSM serving as a catalyst for conversations about articulation between high school and higher education?
- To what extent are mathematics faculty members at institutions of higher education, including community colleges, aware of the CCSSM? What implications, if any, do they see for their mathematics courses?
- How are the design and implementation of college mathematics courses changing in response to the CCSSM and, over time, to the changes in mathematics backgrounds of entering students?

**Professional Societies**

- How are professional societies that are involved in mathematics education responding to the CCSSM in terms of services and resources provided to their members?
- To what extent are these services/resources being used, by whom, and with what results?

**Supplemental Materials**

- What supplemental materials, including assessment tools and on-line resources, are being marketed as aligned with the CCSSM, and in what ways are they aligned?
- How are these materials being used, by whom, and with what results?